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(54) Biological treatment of effluent

(57) Effluents are treated by with heterotrophic or autotrophic micro-organisms, the activated sludge process and the use of algae for purifying waste water. The concentration of the micro-organisms is increased to reduce the structural volume of the reactors. In addition, the separation of suspended matter is improved. The waste water is separated from the micro-organisms by filtration in the biological reactor or in a following stage. By preference, a granular filter layer is used. During the filtration process, this filter layer is cleansed by a special regeneration device.

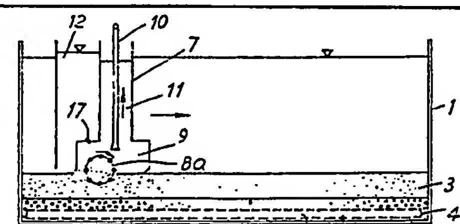

FIG.1A

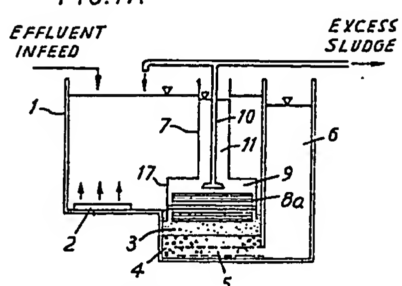

FIG.1B

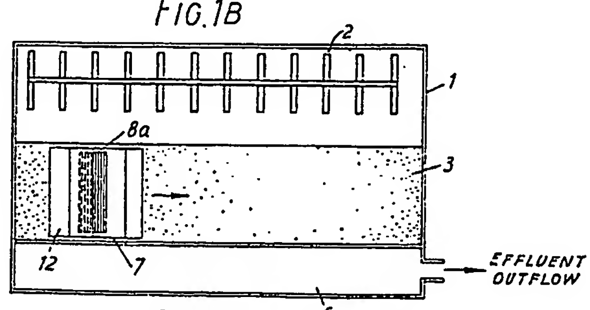

FIG.1C

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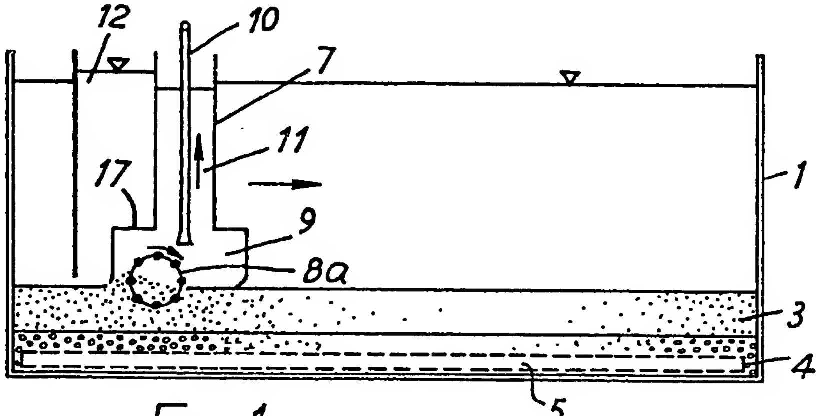


FIG.1A

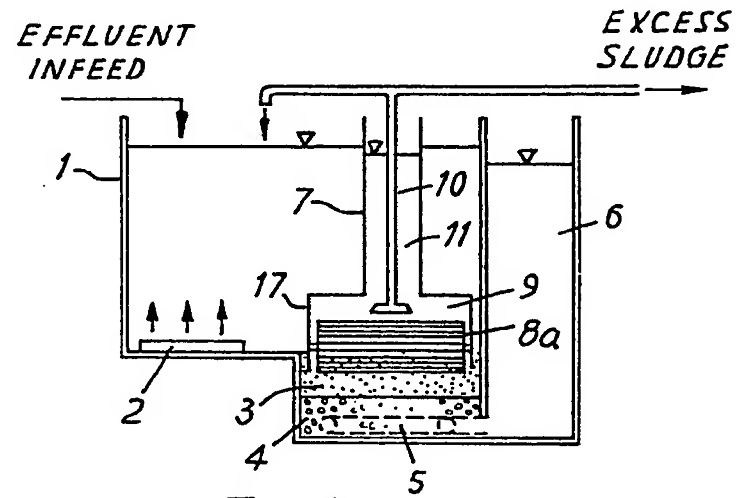


FIG.1B

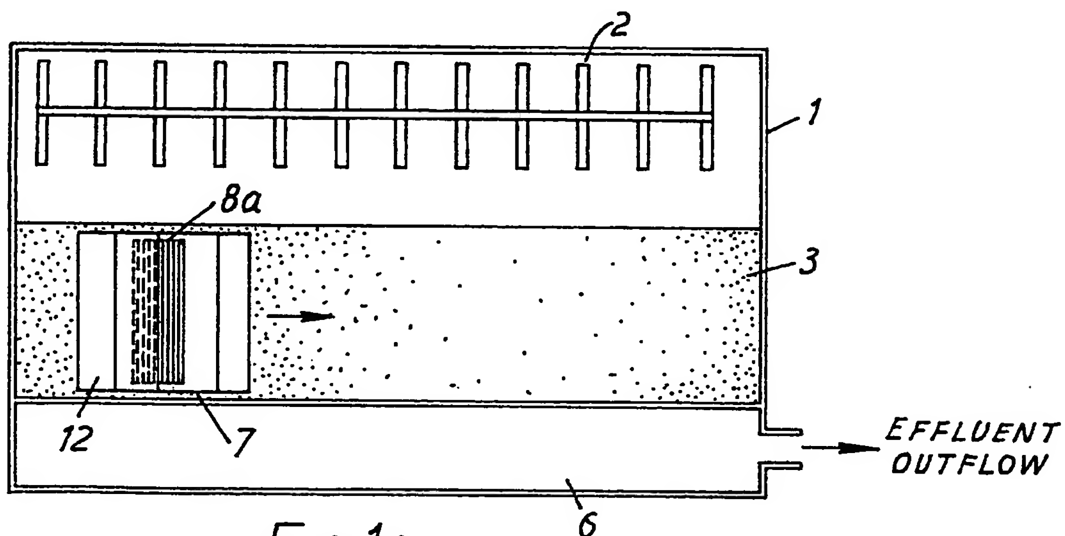


FIG.1C

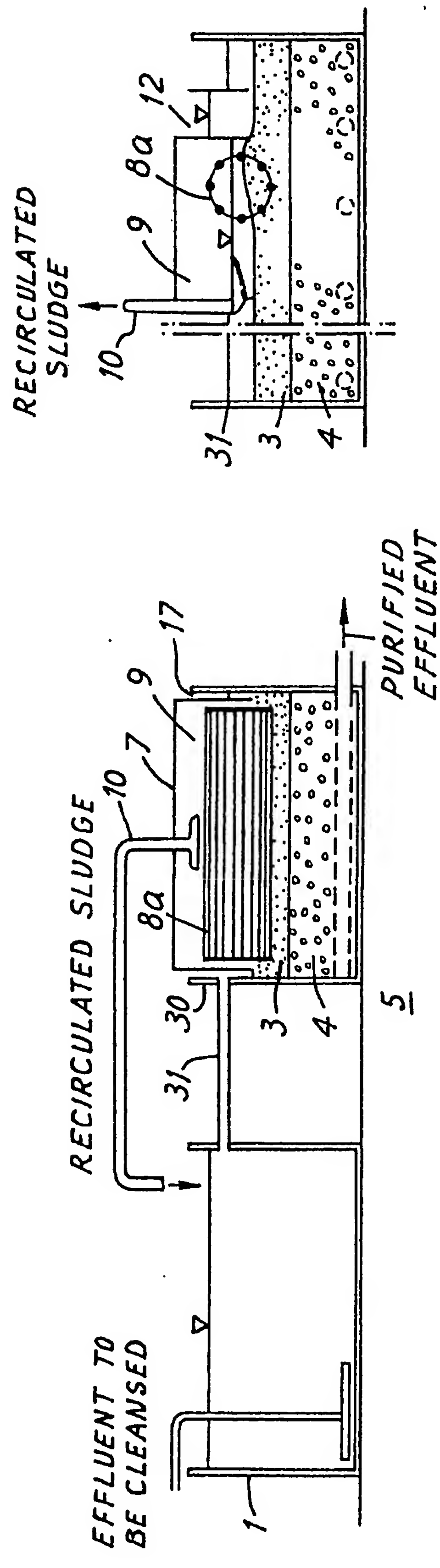
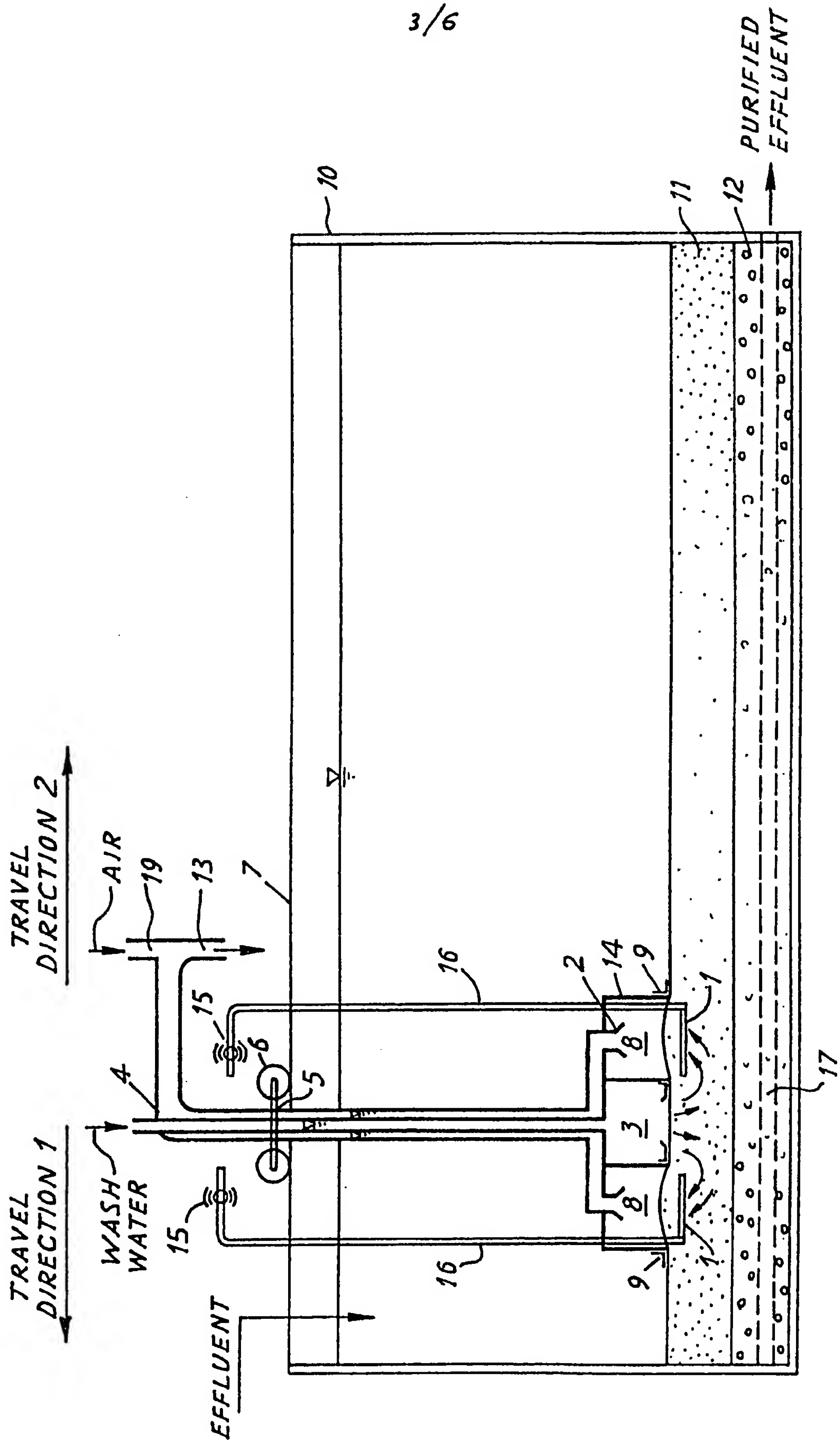

RECIRCULATED SLUDGE
10
9
8a
12
31
3
4
RECIRCULATED SLUDGE
10
7
9
17
PURIFIED EFFLUENT
30
31
3
4
5
EFFLUENT TO BE CLEANSED
1

FIG.2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TRAVEL DIRECTION 1
AIR
WASH WATER
EFFLUENT
PURIFIED EFFLUENT
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
19

FIG.3

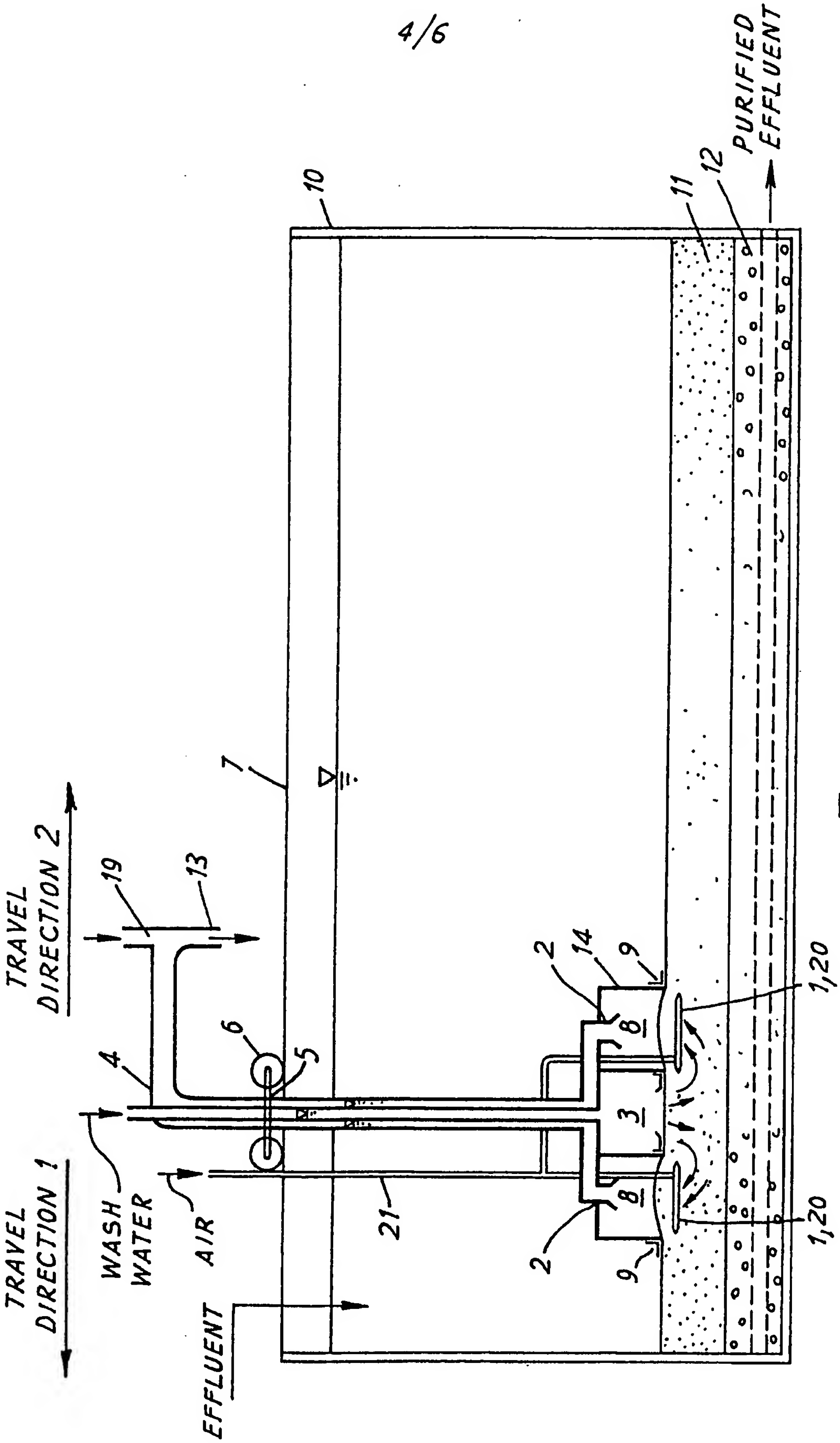
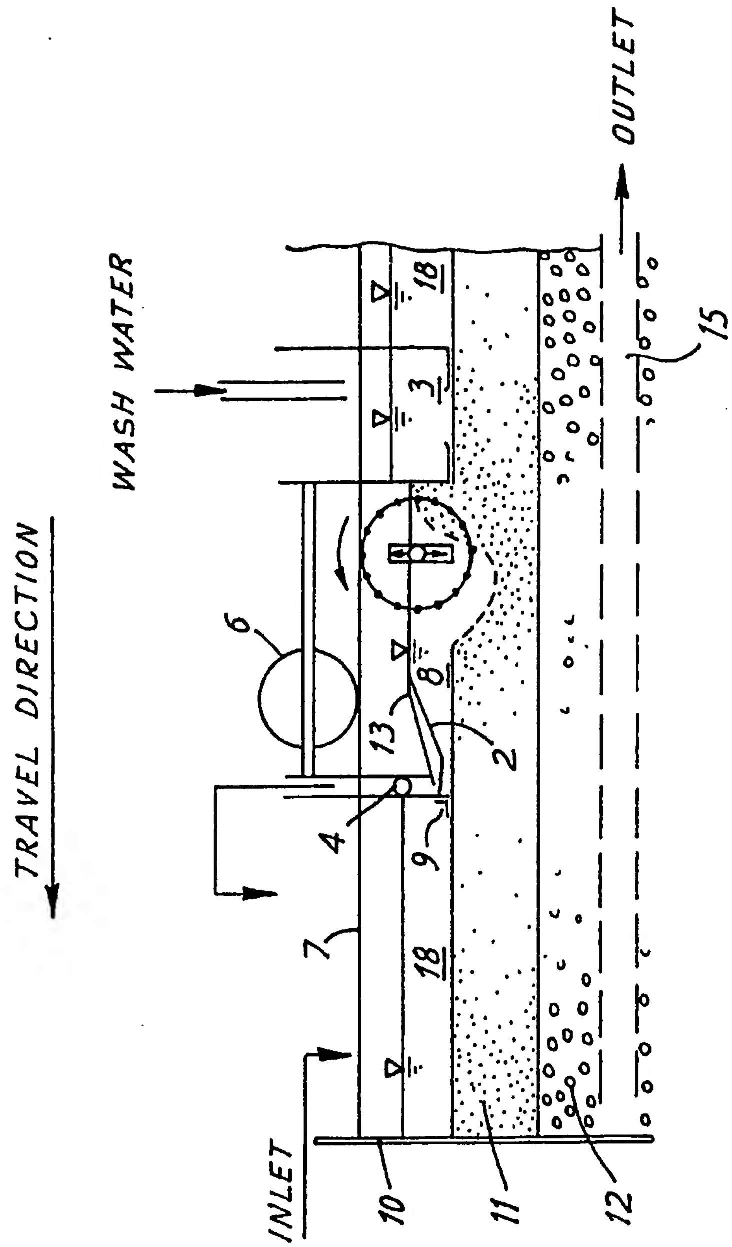

TRAVEL
DIRECTION 2
TRAVEL
DIRECTION 1
WASH
WATER
AIR
EFFLUENT
PURIFIED
EFFLUENT
1
2
3
4
5
6
7
8
9
10
11
12
13
14
19
21
1,20

FIG.4


TRAVEL DIRECTION
WASH WATER
OUTLET
INLET
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18
3
8
13
2
4
9
7
18
10
11
12
15

FIG.5

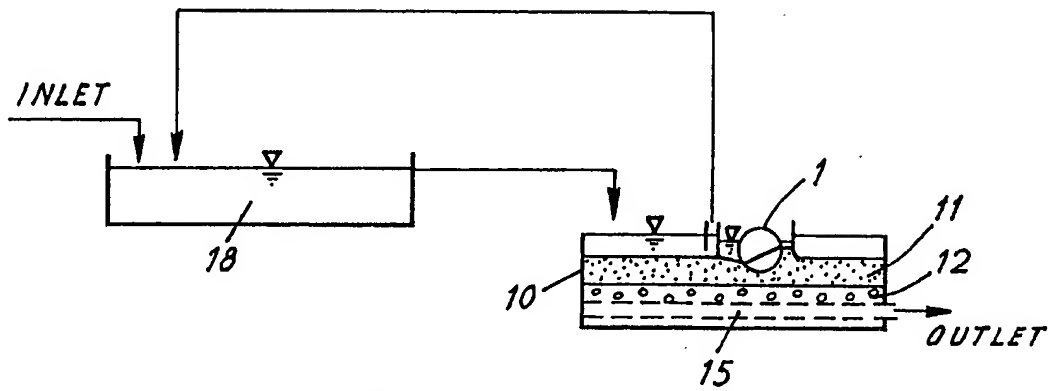

FIG.6

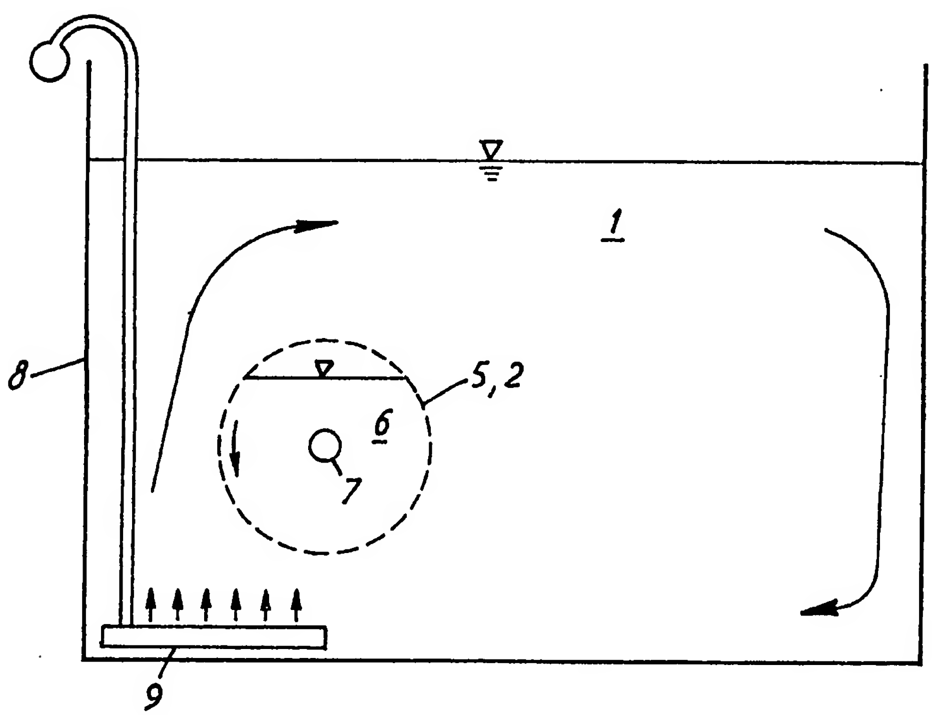

FIG.7

SPECIFICATION

Process and apparatus for the biological treatment of effluent

The invention relates to the biological treatment of effluents with heterotrophic or autotrophic micro-organisms. The process with heterotrophic micro-organisms (activated sludge process) is particularly suitable for the degradation of organic constituents. Autotrophic micro-organisms mainly utilise inorganic nutrient substrates such as phosphorous and nitrogen.

The process according to the invention can be used for communal effluents, as well as for many effluents from industry and agriculture. Moreover, the invention relates to far-reaching removal of suspended matter from waste waters.

For the activated sludge process using heterotrophic micro-organisms, at least two reactors are required according to the hitherto known standard of the art:

In the activated sludge basin, the effluent is mixed with the recycled activated sludge and aerated at the same time. In the sedimentation tank or secondary settler, the sludge is separated from the effluent, e.g. through sedimentation or flotation. The more or less concentrated activated sludge is returned for the most part into the activation basin. The disadvantage of this process is seen mainly in the size of the reactors required.

To reduce the volume of the activation basin, attempts have been made to achieve a higher sludge concentration. For this purpose, the ratio of recycled sludge was increased. However, this is possible only to a limited extent, since this increases the burden of the secondary settler. In order to achieve a higher loading capacity of the secondary settler, special inclusions were fitted in the sedimentation zone, particularly in the form of pipe packages. It was found however, that the space beneath the inclusions was not adequate for concentration of the sludge, because concentration proceeds considerably slower than the first phase of sedimentation.

Another disadvantage of the standard of the art is seen in the not inconsiderable suspended matter emission from the secondary settler.

The heterotrophic micro-organisms have the disadvantage that they cannot synthesise biomasses from the inorganic nutrient substances contained in the water, such as nitrogen and phosphorous. The possibilities of eliminating N and P by means of heterotrophic micro-organisms are limited by the availability of organic carbon compounds. It is necessary therefore, during denitrification, to dosage additional C-compounds or to precipitate the phosphate.

Autotrophic micro-organisms are used in effluent treatment, mainly in effluent ponds. These effluent ponds are suitable only for the treatment of relatively small amounts of effluent, because the dwell time is several days to several months, depending on the concentration of the effluent. The cause for this is seen in that the concentration of the micro-organisms is very low. In order to overcome this disadvantage, which is also present initially when using heterotrophic micro-organisms, a settling tank was arranged downstream of an artificially aerated and recirculated treatment basin, designed for a throughflow time of a few seconds. From this settling tank, the micro-organisms were recycled to the treatment basin. This facility of increasing the concentration is however not suitable for the autotrophic micro-organisms, because these do not precipitate.

The object of the invention is to increase the concentration of heterotrophic and autotrophic micro-organisms to reduce the structural volume of reactors. It is also hoped to achieve a substantial improvement in separating the suspended matter.

The object of the invention is to develop a process with which a high concentration of micro-organisms is possible without gravity concentration, even in the case of turbulence. The separating apparatus should at the same time be usable as a reactor.

The problems are solved by the characteristics indicated in the invention application.

When using filtration, a higher solids content is achieved in a small space. It is also possible to incorporate the filter directly in the reactor. The prevailing turbulence has an advantageous effect in that the deposits forming on the filter are washed-off. Moreover, in this manner, the solids concentration is greatly facilitated, because one can dispense with the otherwise necessary cycle - concentration in the separating device dilution through the incoming waste water in the reactor. For the use of autotrophic micro-organisms at high concentrations, a practical possibility has been achieved for the first time. The filtration process is greatly improved if the micro-organisms in the reactor are combined into compact flocks.

In the preferred embodiment of the invention with a granular filter on the floor of the reactor, or in a following mechanism, a particularly effective regeneration method is used. By this means, due to the envisaged difference in liquid levels within and outside the regeneration chamber, an upwards current is achieved within the vortexing or agitation zone, as the result of which, the deposited sludge is carried upwards and out. The short circuit current under the encompassing walls of the regeneration chamber is prevented by the resultant sand wall when using the wash drum. In addition, it is also possible to use sealing rails. The vortexing or agitation itself is achieved by mechanical means, by oscillations (vibrations) or pneumatically, in described manners. The sludge removed from the regeneration chamber can be recycled to the reactor in the free flow, with an aeration effect taking place at the same time.

When using deep basins, the regeneration chamber is also sealed at the top. Sludge extraction from that point is effected above the liquid level.

With highly concentrated suspensions, it is advantageous to achieve a pronounced seepage effect immediately behind the vortexing (agitation) device, through the use of washing water in a special chamber.

During filtration, the regeneration apparatus is operated at certain intervals over the filter, so that the whole filter area is cleansed.

When using a filter drum, adequately large shear forces are developed by its rotation, in order to ensure the function over a longer period of time. It is particularly advantageous if during pressurised aeration, the rotation takes place counter to the flow rotation established in the basin.

The invention will be described below on the basis of 7 embodiments, with reference to the accompanying diagrammatic drawings, in which:

Example 1 (Figure 1) Apparatus for purifying waste water by arranging a granular filter layer in the sludge activation basin and regenerating with a rotation roller;

Example 2 (Figure 2) Apparatus for cleansing waste water with activated sludge basins and following granular filter layer, as well as regeneration with a rotating roller;

Example 3 (Figure 3) Aoparatus for purifying waste water by arranging a granular filter layer in the sludge activation basin and regeneration through oscillation (vibrations);

Example 4 (Figure 4) Apparatus for purifying waste water by arranging a granular filter bed in the activation basin and regeneration through air injection;

Example 5 (Figure 5) Apparatus for purifying waste water in an algae basin with granular filter bed, and regeneration with a rotating roller;

Example 6 (Figure 6) Apparatus for purifying waste water in an algae basin with following granular filter bed and regeneration with a rotating roller;

Example 7 (Figure 7) Apparatus for purifying waste water with filter drums in the activation basin.

Example 1

Arranged at one side within an elongated basin 1, measuring 6 metres wide and 3.5 m deep, are the filter tubes for pressure aeration 2. On the other side of the basin there is a 3 m wide strip of a filter bed 3 of 40 cm depth, with a grain size of 0.5 to 1 mm. Beneath this is a support layer 4 with a drainage 5, which terminates in the laterally located compartment 6 for the purified waste water. The activated sludge basin is operated at a sludge concentration of 7 g/l and a dwell time of 2 hours. The waste water input (communal waste water) is fed in over the whole basin length. Through the filter layer, 3.5 m^3/m^2. hour, purified water with a BSB_5 rating of less than 10 mg/l is withdrawn. In order to maintain the high percolating efficiency, there is continuous regeneration by means of the underwater-functioning sand-cleansing apparatus 7.

The sand-cleansing apparatus 7 consists of a rotating wash drum 8a of 40 cm diameter and 1.3 m length. It is preferably in the form of horizontal lengthwise rods. The wash drum 8a is secured to the basic frame 13 and enveloped by lateral walls 17. Together with the upper closure and the filter surface, these walls 17 form an enclosed compartment 9. Above this is the extraction shaft 11. From this shaft, the vortexing or agitated sludge is pumped away via the pipe 10 and recycled to the activated sludge basin 1. A portion is removed as excess sludge. For the purpose of generating the upwards current, a higher water level is maintained in the wash water vessel 12.

Example 2

The effluent/sludge mixture is transferred via the pipe 31 into the filtering apparatus 30. There, the waste water seeps through the granular filter bed 3 and passes through the support layer 4 and the drainage 5 into the outlet. The sludge is concentrated at the surface of the filter bed 3. For the purpose of cleansing the filter bed 3, the wash water vessel 12 is filled with previously purified waste water. Thereafter, the filter-cleansing apparatus 7 is moved over the filter surface. Because of the higher water level in the wash water vessel 12, an upwards flowing current is generated in the filter bed 3 beneath the enclosed compartment 9 encompassed by the lateral walls 17, as a result of which, in conjuction with the rotation of the wash drum 8a, the solids are extracted from the filter bed 3. These solids are returned to the activated sludge basin 1 via the extraction device 10.

Example 3

On the floor of an elongated basin 1, measuring 6 m wide and 3.5 m deep, there is a filter layer 3 on a support layer 4 with drainage 5. The filter layer 3 is 30 cm thick with a grain size of less than 1 mm. Within the basin, an activated sludge concentration of 10 g/l is maintained. The dwell time is 1.5 hours. With a useful basin depth of 3 metres, a filter speed of 2 m/h is set. At intervals of about 1 hour, the filter layer 3 is regenerated. The regeneration appliance 7 comprises a basic frame 13 with travel mechanism 14, moving in the lengthwise direction on the basin edge, e.g. on rails.

The vortexing or agitation of the filter layer 3 is effected via the vibration grids 8b. The extracted sludge is taken from the enclosed compartments 9 via the sludge extractor 10, and raised by the sludge conveyor pipeline 11 to a level above the liquid level. From the sludge outlet 33, a free jet falls onto the liquid, thereby creating an oxygen enrichment. This can be increased even further by a shaft overflow or injector 21. Because of the increased wash water level 12, an upwards directed current is created in the agitation zone which prevents soiling of the sand layer depth. The vibration grids 8b are excited to a frequency of 100 s^{-1} by the oscillation inducer 18 via the vibration transmitter 19.

Example 4

On the floor of an elongated basin 10, measuring 6 m wide and 3.5 m deep, there is a filter layer 3 on a support layer 4 with drainage 5. The filter layer is 30 cm thick and has a grain size of less than 1 mm. Within the basin, an activated sludge concentration of 10 g/l is maintained. The dwell time is 1.5 hours. With a useful basin depth of 3 m,

a filter speed of 2 m/h is set. At intervals of about 1 hour, the filter layer 3 is regenerated by a system of jets 8c, mounted on an aeration grid. The aeration grid 8c is lowered to a depth of 10 cm into the filter layer 3. The regeneration device 7 comprises a basic frame 13 with travel facility 14, so as to move along the length of the basin, for example on rails 15 fitted on the basin edge. The extracted sludge is picked up from the enclosed compartments 9 by the sludge extractor 10, and raised to a level above the liquid level via the sludge conveyor pipeline 11. From the sludge outlet 33, a free jet falls onto the liquid, thus giving rise to an oxygen enrichment. This can be increased even further by a shaft overflow or an injector 22. Because of the raised washing water level 12, there is an upward current in the agitation zone, thus preventing soiling of the lower depth of the filter.

It is also possible to excite the aeration grid 8c to a predetermined frequency, e.g. 100 s^{-1}.

Example 5

The illustration shows a granular filter layer 3, resting on a support layer 4 with drainage 5. Above this is the water head compartment 32 with about 20 cm water height. Within the water head compartment 32, an algae suspension of the chlorella species is kept. The bio-mass concentration is 2.5 g/l. Because of the high bio-mass content, the dwell time can be reduced to about 6 hours when purifying communal effluent.

The cleaning apparatus comprises a basic frame 13 which moves on bogey wheels 14 on rails or on concrete tracks 15 along the basin length. The wash drum 8a is secured to the basic frame 13, and can be lowered according to the required regeneration depth (3 to 25 cm). From the basic frame 13 and parallel to the rails 15, side walls 17 extend down into the filter sand. The trailing demarcation of the enclosed working compartment 9 is formed by a resultant sandwall. The leading seal is effected mechanically by a sealing strip 16. The sludge channel 10 is attached to the basic frame 13, and can be lowered, according to the necessary regeneration depth (3 to 25 cm). From the basic frame 13 and parallel to the rails 15, side walls 17 extend downwards into the filter sand. The overflow lip of the sludge channel 13 is adjustable in height, so that the necessary outflow volume can be regulated. The wash drum 8a rotates at a speed of 30 to 40 rpm, while the whole appliance moves forwards at a speed of 0.25 to 0.42 m/min. The sludge water extraction is 60 to 100 l/min, based on a wash drum of 1 metre. Behind the enclosed working compartment 9 there is an open-bottom vessel 12 for feeding-in washing water. Previously purified waste water is used as wash water. Because of the raised water level in the wash water vessel 12, an upwards current is created in the filter layer 3 in the region of the wash drum 8a, as the result of which, deposited solids are extracted.

Example 6

The reactor basin 1 may be in the form of simple concrete or earth basins with a low water level. In the case of higher filling levels, a circulating device is necessary, so that all micro-organisms are periodically subjected to light. The reaction basin 1 contains an algae suspension of the species chlorella, with a bio-mass concentration of 2.5 g.l. Because of the high bio-mass content, communal waste waters can be purified in about 6 hours. The algae suspension is transferred into the filter basin 30, where the water is filtered through the granular filter layer 3. In so doing, the algae are concentrated to 10 g/l dry substance, and returned to the reaction basin 1.

Example 7

In a rectangular activated sludge basin 1, a pressurised aeration device 2 is arranged on one long wall. This gives rise to the known form of circulating current. In the vicinity of the wall 29, there is a series of filter drums 26, these are clothed with a micro-sieve fabric 23. The waste water to be discharged, passes through the micro-sieve fabric 23 and flows through the outlet 28. As the result of the consequent concentration polarisation, the filter speed is reduced. It is therefore necessary to create a sufficiently large shear force at the filter surface. To this end, the filter frums 5 are caused to rotate. To increase this action, the rotation is in counter direction to the ascending liquid current.

CLAIMS

1. Process for the biological treatment of effluents, whereby the effluent is brought into contact with suspended micro-organisms, and the treatment time is substantially shorter than the growth period of the micro-organisms, characterised in that the effluent is separated from the micro-organisms by filtration in a biological reactor (1) or in a subsequent stage (30), and the micro-organisms are enriched in the biological reactor (1).

2. Process according to Claim 1, wherein heterotrophic micro-organisms are enriched in the biological reactor (1).

3. Process according to Claim 1, wherein autotrophic micro-organisms are enriched in the biological reactor (1).

4. Process according to Claim 1, wherein the micro-organisms from the following stage (30) are recirculated into the biological reactor (1).

5. Process according to Claims 1 to 3, wherein the micro-organisms are combined into macroscopic flock.

6. Process according to Claim 1, wherein the effluent is separated from the micro-organisms by filtration through a sieve fabric (23).

7. Process according to Claim 1, wherein the effluent is separated from the micro-organisms by filtration through a filter membrane (24).

8. Process according to Claim 1, wherein the effluent is separated from the micro-organisms by filtration through a porous filter layer (25).

9. Process according to Claim 1, wherein the effluent is separated from the micro-organisms by filtration through a granular filter layer (3).

10. Process according to Claims 1, 6, 7, 8, 9

wherein a current is established parallel to the filter surface.

11. Process according to Claim 9, wherein the granular filter layer (3) is agitated constantly or at given intervals, said agitation being in a layer close to the surface, within an area (9) enclosed by side walls (17), such that the enclosed space (9) is moved over the filter layer (3) whilst an upwards current is maintained in the agitated filter layer (3), and the sludge is extracted from the enclosed compartment (9).

12. Process according to Claim 1, wherein the ascending current in the granular filter layer (3) is created by lowering the liquid level within the enclosed compartment (9).

13. Process according to Claim 11, wherein the ascending current in the granular filter layer is created by establishing a higher liquid level in the region alongside the agitation (9).

14. Process according to Claim 1, wherein the sludge from the enclosed compartment (9) is wholly or partially returned to the biological reactor.

15. Process according to Claim 11, wherein the granular filter layer (3) is agitated by a rotation roller (8a) with horizontal axis.

16. Process according to Claim 11, wherein the granular filter layer (3) is agitated by mechanical vibrations (8b).

17. Process according to Claim 16, wherein the granular filter layer (3) is excited to the inherent frequency of the liquid, to the mean inherent frequency of the flow pipe system, or to the mean inherent frequency of the filter grain.

18. Process according to Claim 1, wherein the granular layer (3) is agitated by injecting a gas.

19. Apparatus for carrying out the process according to Claim 1, 6, 7, 8 and 10, wherein within a reaction basin (1), at least one rotating filter drum (26) is provided, having a porous filter layer (25), or being covered with a sieve fabric (23) or a filter membrane (24), and the interior (27) of the filter drum (26) being provided with an outlet (28).

20. Apparatus according to Claim 19, wherein the filter drum (26) has a horizontal axis and is fitted in the vicinity of the wall (29) of the reaction basin (1) and to which an aeration device is fitted, and the side of the filter drum (26) nearest the basin wall (29) undergoes a downward motion counter to the ascending liquid.

21. Apparatus for carrying out the process according to Claims 1 and 9, wherein on the floor of a reaction basin (1) there is a granular filter layer (3) with support layer (4) and drainage (5) or a filter base (20), and on a portion of the filter layer (3), an open-bottom, movable compartment (9), enclosed by side walls (17) is located, said compartment (9) being fitted with a sludge extraction device (19), and also an agitation device (8) being provided inside the compartment (9).

22. Apparatus according to Claim 21, wherein an open-bottom wash water vessel (12) is provided alongside the enclosed compartment (9).

23. Apparatus according to Claims 21 and 22, wherein the compartment (9), enclosed by side walls (17), is also closed at the top, and is fitted with a sludge conveying line (11) extending above the liquid level in the reaction basin (1) and also with a wash water inlet (12), extending above the liquid level.

24. Apparatus according to Claim 21, wherein the agitation device (8) is in the form of a rotating wash drum (8a) with horizontal axis.

25. Apparatus according to Claim 21, wherein the agitation device (8) is in the form of a vibration grid (8b) which is fitted with an oscillation generator (18) via a vibration transmitter, located above the liquid level.

26. Apparatus according to Claim 21, wherein the agitation device (8) comprises a number of jets (8c) for injecting gas, and which are connected to a gas supply line (22).

27. Process for the biological treatment of effluents substantially as herein described.

28. Apparatus for the biological treatment of effluents constructed, arranged and adapted to operate substantially as herein described with reference to, and as shown in, the accompanying drawings.

29. Effluent biologically treated by an apparatus according to any one of Claims 19 to 26 or 28.

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